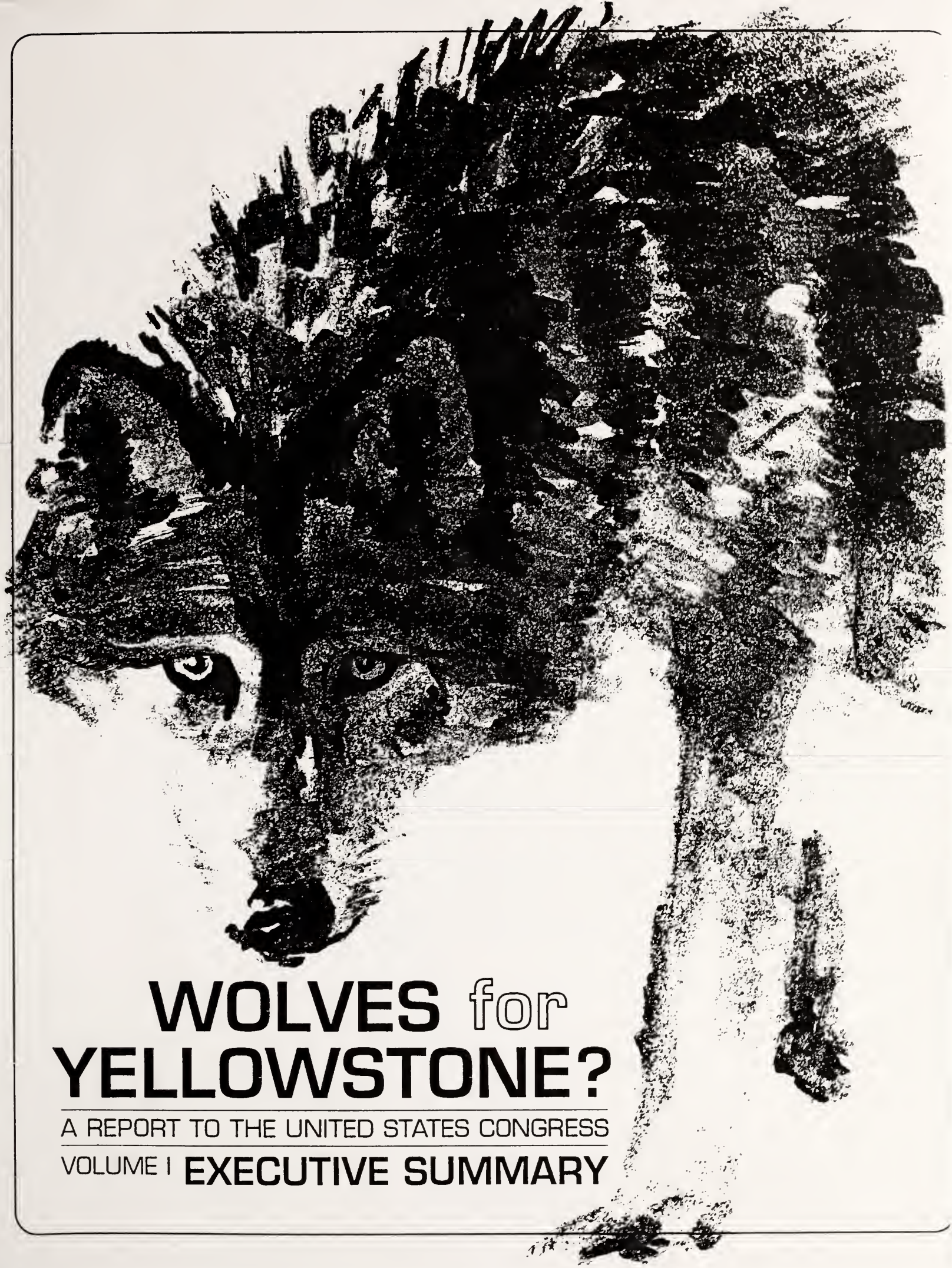

WOLVES for YELLOWSTONE?

A REPORT TO THE UNITED STATES CONGRESS

VOLUME I **EXECUTIVE SUMMARY**

WOLVES FOR YELLOWSTONE?

A Report to the United States Congress

Volume I Executive Summaries

WOLVES FOR YELLOWSTONE?
A REPORT TO THE UNITED STATES CONGRESS
VOLUME I EXECUTIVE SUMMARIES

Prepared by

Yellowstone National Park

U.S. Fish and Wildlife Service

University of Wyoming

University of Idaho

Interagency Grizzly Bear Study Team

University of Minnesota Cooperative Park Studies Unit

Published May 1990

Digitized by the Internet Archive
in 2014

https://archive.org/details/wolvesforyellows01varl

TABLE OF CONTENTS

Page

Table of Contents.....V
Introduction.....1

SECTION 1 Control and Management of Wolves

Management of Wolves Inside and Outside Yellowstone National Park and Possibilities for Wolf Management Zones in the Greater Yellowstone Area. Steven H. Fritts.....3

SECTION 2 The Prey Base for Wolves in Yellowstone National Park

The Ungulate Prey Base for Wolves in Yellowstone National Park I. Francis J. Singer.....5

The Ungulate Prey Base for Wolves in Yellowstone National Park II. John A. Mack, Francis J. Singer, Mary E. Messaros....7

Distribution of Beaver in Yellowstone National Park 1988-1989. Susan L. Consolo, Donay D. Hanson.....19

SECTION 3 Computer Simulation Models

Wolf Recovery for Yellowstone National Park: A Simulation Model. Mark S. Boyce.....21

The Potential Impact of a Reintroduced Wolf Population on the Northern Yellowstone Elk Herd. Edward O. Garton, Robert L. Crabtree, Bruce B. Ackerman and Gerald Wright.....23

Estimates of the Potential Interactions Between Hunter Harvest and Wolf Predation on the Sand Creek, Idaho and Gallatin, Montana, Elk Populations.
David J. Vales, James M. Peek.....25

SECTION 4 Predicted Effects of Wolf Restoration

Some Predicted Effects Concerning a Wolf Recovery Into Yellowstone National Park. Francis J. Singer.....27

Possible Effects of a Restored Wolf Population on Grizzly Bears in the Yellowstone Area.
Christopher W. Servheen, Richard R. Knight.....29

Effects of Restoring Wolves on Yellowstone Area Big Game and Grizzly Bears: Opinions of Fifteen North American Experts.
Barbara Koth, David W. Lime and Jonathan Vlaming.....31

SECTION 5 Proposed Studies for 1990. John D. Varley.....37

Acknowledgments.....38

INTRODUCTION

The gray wolf (Canis lupus) was eliminated from Yellowstone National Park by the 1930s. Fifty years later, the gray wolf was listed as an endangered species in the northern Rocky Mountains. Under authority of the Endangered Species Act of 1973, recovery plans for the northern Rocky Mountain wolf were approved in 1980 and 1987.

The Northern Rocky Mountain Wolf Recovery Plan offers strategies for conserving wolves in three areas of the northern Rockies: northwest Montana, central Idaho, and the greater Yellowstone area. In the first two areas, the plan projects that wolves would naturally recolonize. A small population of wolves has colonized an area in northwest Montana in the last decade, and there are persistent reports of wolves in central Idaho.

Due to Yellowstone's geographic isolation from areas with established wolf populations, the recovery plan proposes translocating wolves to the Yellowstone recovery area. That proposal raised a number of questions and concerns about the potential effects of restoring wolves to Yellowstone.

Wolves for Yellowstone? A Report to the United States Congress, Volume I Executive Summaries contains the detailed results of ten studies designed to answer four questions posed in 1988 by the Senate-House Interior Appropriations Conference Committee (paraphrased): 1) Would wolves be controlled inside or outside of Yellowstone?, 2) How might a reintroduced population of wolves affect the prey base in Yellowstone and big game hunting in areas surrounding the park?, 3) Would a reintroduced population of wolves harm or benefit grizzly bears in and near the park?, and 4) How would wolf management zones be delineated? Congress provided the National Park Service and the U.S. Fish and Wildlife Service with $200,000 to answer these and related questions.

The National Park Service and the U.S. Fish and Wildlife Service used three different approaches to answer the four questions: 1) extensive literature surveys; 2) consulting and compiling the opinions of 15 experts on North American wolves, bears, and ungulates through a process known as the Delphi technique, and consulting nine experts on Eurasian wolves, bears, and ungulates; and 3) three computer simulations by predator/prey dynamics modelers at two universities. Wildlife agencies of Idaho, Montana, and Wyoming furnished data on big game numbers and harvests for several of the studies.

The conclusions and opinions expressed in the studies and in these executive summaries are those of the authors and panelists. They were asked to evaluate the potential effects of wolf recovery in relation to the

four questions posed by Congress. They were not asked to evaluate the desirability of wolf recovery in Yellowstone.

Some of the studies summarized here should be considered progress reports; the authors will want to read what others have written on these topics, and they may wish to modify their conclusions based on more complete information. For instance, not all data on Yellowstone area wolf prey numbers, ungulate ranges, and harvests were available to the 15 Delphi panelists (wolf/prey experts) when they offered their opinions on questions posed to them.

Readers should recognize that these are summaries. The complete report (Wolves for Yellowstone? A Report to the United States Congress, Volume II Research and Analysis) is 650 pages in length, with many figures, graphs, tables, and literature citations.

Questions remain and funding to study them has been appropriated for 1990. Some questions can never be answered definitively unless wolves are experimentally restored and studied in Yellowstone.

MANAGEMENT OF WOLVES INSIDE AND OUTSIDE YELLOWSTONE NATIONAL PARK AND POSSIBILITIES FOR WOLF MANAGEMENT ZONES IN THE GREATER YELLOWSTONE AREA

Steven H. Fritts, U.S. Fish and Wildlife Service, Federal Building, U.S. Courthouse, 301 South Park, Helena, MT 59626

EXECUTIVE SUMMARY

1. The need for control of wolves (Canis lupus) within Yellowstone National Park is expected to be negligible and limited mainly to occasional control of nuisance animals.

2. Any control is likely to be controversial. Some control will be needed outside the park to address occasional depredations on livestock and, possibly, to control excessive predation on ungulates.

3. The situation appears to be suited for reintroduction under Section 10(j) of the Endangered Species Act as a nonessential experimental population.

4. If a reintroduced population was classified as experimental and nonessential per Section 10(j) of the Endangered Species Act, federal agencies would only have to confer informally with the U.S. Fish and Wildlife Service (FWS) on activities that might jeopardize the species (except in national parks and national wildlife refuges). A jeopardy ruling by the FWS would not prohibit the federal agency from committing resources to the proposed activity. Therefore, land-use restrictions are not expected to be major issues.

5. Discussions with the Office of the Solicitor, Department of Interior, and review of the legislative history of Section 10(j) of the Endangered Species Act reveal that Congress intended broad flexibility for controlling experimental populations in order to make more reintroductions possible. The full extent of control possible under Section 10(j) has not been tested.

6. The court case of Sierra Club et al. vs. Clark et al. (1985) in Minnesota did not pertain to experimental populations and therefore will not affect the management of wolves in the greater Yellowstone area (GYA).

7. The experimental population designation was recently used to successfully reintroduce the red wolf (Canis rufus) to the wild; an account of that case with discussion of control methods used is provided.

8. Presence of wolves in Yellowstone National Park would not preclude usual recreational activities in the park or surrounding lands. Wolves would not be a significant threat to human safety.

9. If wolves were to colonize the GYA (including Yellowstone National Park) on their own, the opportunity for management flexibility via experimental population designation would be lost, and wolves would receive the full protection of the Endangered Species Act.

10. The purpose of this report was not to make specific recommendations about wolf control and management zones for wolves in the GYA but to identify and give advantages and disadvantages of some of the numerous options available. Various scenarios are discussed, ranging from intensive control with public involvement to no control or minor control conducted by state or federal officials. In general, less control means increased potential for conflicts but reduced risk to the wolf population, reduced time to recovery (10 breeding pairs) and delisting, and greater probability of reaching recovery level. Conversely, more control means fewer conflicts but increased risk to the wolf population, more time required to reach recovery and delisting, and reduced chance of achieving recovery level. The opportunity exists to craft management that will both allow wolf recovery and address the potential conflicts in the GYA.

11. An integral question to the management (and therefore, to establishment of management zones) of wolves in the GYA is how much area wolves would require for a secure population to be established. No research, short of placing wolves in the park, can answer that question without conjecture.

THE UNGULATE PREY BASE FOR WOLVES IN YELLOWSTONE NATIONAL PARK I: Five Species on the Northern Range, Elk Parkwide

Francis J. Singer, National Park Service, Division of Research,
P.O. Box 168, Yellowstone National Park, WY 82190

EXECUTIVE SUMMARY

1. Population and harvest data from the 1980's are presented for eight ungulate species that occur in Yellowstone National Park: bighorn sheep (Ovis canadensis) bison (Bison bison), elk (Cervus elaphus), mule deer (Odocoileus hemionus), moose (Alces alces), mountain goat (Oreamnos americanus) pronghorn (Antilocapra americana), and white-tailed deer (Odocoileus virginianus). Five of these ungulates, elk, mule deer, moose, white-tailed deer and pronghorn utilize Yellowstone's northern range. Data are also presented for the eight elk herds that winter, summer, or reside year-round within the park boundary including the Clarks Fork, North Fork Shoshone, Carter Mountain, Jackson, Sand Creek, Gallatin, and Madison-Firehole herds.

2. During the period 1980-1988, an average of about 17,457 (range of counts 10,226-19,000) elk wintered on Yellowstone's northern range, and about 1,900 elk wintered on three other ranges within Yellowstone National Park. Mule deer counts averaged 1,914 (1,007-2,274), pronghorn 392 (102-495), bison 433 (233-594), and bighorn sheep 195 (218-607) on the northern winter range. A minimally recovered wolf population of 10 pairs of about 100 wolves would correspond to the following mean ratios for the 1980-1988 period: 1) 1 wolf:145 ungulates on the northern winter range within the park (14,491 ungulates), 2) 1 wolf:231 ungulates for all of the northern winter range and all other park winter ranges combined (23,085 ungulates), and 3) 1 wolf:186 ungulates for all of the northern range both inside and outside Yellowstone National Park (18,555 ungulates).

3. During the period 1980-1988, the eight species of ungulates occupying Yellowstone National Park during summer exceeded 37,804 individuals. A mean estimated 31,136 elk from eight herds spent the summer within the park. Summering elk spent an average of 138-160 days in the park, or about 38%-43% of the year. A minimally-recovered wolf population of 10 pairs or about 100 wolves would correspond to the following mean ratios for the 1980-1988 period: 1 wolf:378 ungulates during summer parkwide (37,804 ungulates). Wolf to ungulate ratios ranged from 1 wolf:96 to 1 wolf:328 ungulates in seven wolf-occupied areas elsewhere in North America. Yellowstone's summer ungulate numbers are underestimated since an unknown additional number of mule deer and moose migrate into the park each summer. Hunters also utilize the ungulate prey base, as do other predators within Yellowstone Park. These predators include grizzly bears (Ursus arctos),

black bears (Ursus americanus), coyotes (Canis latrans), and mountain lions (Felis concolor). Wolf to ungulate ratios should be used for preliminary estimates only because of:

1) functional responses of wolves to changes in prey densities,

2) lags in numerical responses of wolves,

3) the role of buffer prey species, and

4) differences due to the proximity of the ungulate population to its nutrient-climate ceiling.

4. The 1988 drought reduced plant biomass and caused early plant senescence, while the 1988 fires burned portions of winter ranges in the fall. Several arctic storm fronts exacerbated winter severity. As a result, during the winter of 1988-1989, many ungulates were winterkilled and the late season harvest of elk increased. Due to both of these factors, elk population estimates for the northern winter range declined 40%; mule deer counts declined 21%, and pronghorn counts declined 25%. Recovery to at least prefire levels is necessary before gray wolves (Canis lupus) could be restored to Yellowstone.

ERRATA SHEET

Page	Error
6	Last paragraph, last sentence, should read: Recovery to at least prefire levels would probably occur before gray wolves (Canis lupus) could be restored to Yellowstone given that the restoration process would take several years.

THE UNGULATE PREY BASE FOR WOLVES IN YELLOWSTONE NATIONAL PARK II: Elk, Mule Deer, White-tailed Deer, Moose, Bighorn Sheep, and Mountain Goats in the Areas Adjacent to the Park

John A. Mack, Francis J. Singer, and Mary E. Messaros,
National Park Service, Division of Research,
Yellowstone National Park, WY 82190

EXECUTIVE SUMMARY

Elk

Portions of eight elk (Cervus elaphus) herds occupy Yellowstone National Park during the summer with 25,000-31,000 elk summering in the park annually in the 1980's. Summer estimates of the eight herds total 36,000-49,000 elk; including animals that summer outside the park. Winter ranges for three herds (Carter Mountain, Jackson, and Sand Creek) are quite distant from areas gray wolves (Canis lupus) would likely occupy. Portions of four elk herds, totaling about 13,480-20,880 elk, winter within Yellowstone National Park. These four herds include portions of the northern herd (11,600-19,000 elk), the Gallatin herd (about 580), the Madison-Firehole (800-1,400), and the North Fork Shoshone herd (Thorofare group, about 500 elk). Annual harvests for the eight herds averaged 7,032 elk during the 1980's.

Population Trends

During the last 20 years, population estimates for eight elk herds increased dramatically by about 17,000 elk (80% increase). Population estimates for the Sand Creek and northern range herds increased about fourfold. The Jackson and Madison-Firehole herds remained relatively stable. The Gallatin herd was reduced but then increased slightly during the last 20 years. Population estimates of elk from seven herds increased an average of 38% (range 10-67%) during the 1980's (Table 1). Only the Madison-Firehole herd declined. Currently, elk numbers for the Jackson, Carter Mountain, North Fork Shoshone, Clarks Fork, and Sand Creek herds exceed management goals.

Table 1. Elk population statistics for 8 elk herds located within and/or adjacent to Yellowstone National Park (YNP) during the 1980's.

Herd Unit	Estimated Population Size	Mean Harvest 1980's	Percent Population Change 1980's	Percent Herd That Summer in YNP[1]	Mean Days in YNP During Summer	Distance (km) of Winter Range From YNP	Sex and Age Class of Harvest (%)			
							Spike Bulls	Bulls	Adult Cows	Calves
Gallatin	2,500	912	+20[2]	48	150	includes YNP	35	37	24	3
Northern	16,500-21,000	1,401	+31	90	---	includes YNP	10	23	45	22
Clarks Fork	3,000	713	+67	83	160	32	14	33	44	9
North Fork Shoshone	2,800	570	+64	78	160	8-13	21	43	32	4
Carter Mountain	3,000	658	+55	a few	---	48	25	26	39	10
Jackson	11,000	2,530	+18	28	150	48	|--53[3]--|		36	11
Sand Creek	3,800-4,900	914	+10	21	138-150	64	32	31	37[4]	---
Madison-Firehole	800-1,400	tr	decline	100	---	includes YNP	---	---	---	---
Total	43,400-49,600	7,698								
Mean			+38							

[1] Based upon movements of 386 radio collared elk.
[2] Increase occurred almost entirely in the Madison River segment of the herd.
[3] Includes spikes and bulls.
[4] Includes some calves.

Sources: Craighead et al. (1973), Houston (1982), Rudd (1982), Rudd et al. (1983), Brown (1985), Trent et al. (1985), Carlson (1987), Yorgason et al. (1987), Hurley et al. (1989), Boyce (1989), Singer (1990), B. Smith per. commun.

Migrations

Seven elk herds are strongly migratory and the Madison-Firehole herd is nonmigratory. Distances between winter and summer ranges vary from 8-64 km (5-40 miles). Spring migrations to summer range for the Sand Creek herd lasted 46 days. Calving for migratory elk typically occurs enroute to summer ranges; except during springs with less snow when calving may occur on summer ranges. Calves born to elk migrating long distances may occasionally be available to wolves. Use of summer ranges in Yellowstone varied from 138 to 160 days (Table 1). Fall migrations to winter ranges averaged 19 days for the Jackson elk herd and 27 days for the Sand Creek herd. Migration patterns changed little over the past 20 years. Exceptions include: a) a higher proportion of northern range elk summer west of Yellowstone Lake, b) a former migration of about 800 elk from the Jackson herd to southwest Yellowstone National Park (Cole 1969) was reduced to 100-150 by the late 1970's (B. Smith, in prep.), c) the proportion of Jackson elk migrating into Yellowstone National Park and the Teton Wilderness through the Togwotee Pass area has declined.

Mule Deer

North and Northwest of Yellowstone National Park

Mule deer (Odocoileus hemionus) populations increased dramatically north of Yellowstone National Park in Montana. Helicopter counts of mule deer on the northern range increased 78% (from 1,007 to 1,795) during the 1980's (Table 2). An increase in the harvest in the upper Gallatin suggests mule deer may have increased there also. Deer harvests averaged 726 per year, of which about 9% were white-tailed deer (Odocoileus virgianus). Antlerless harvests in Montana increased fivefold during the 1980's due to management efforts to reduce deer populations. A few deer from other areas in Montana may migrate into Yellowstone National Park. Two adult does marked on the Boulder River summered near Slough Creek campground and one doe from the Bridger Mountains summered near Madison Junction.

East of Yellowstone National Park

Mule deer population estimates east of the park increased about 77% during the 1980's to about 14,000 according to computer models (Table 2). Harvests averaged 1,599 per year during the 1980's. Some mule deer from the Clarks Fork, North Fork Shoshone, and South Fork Shoshone probably migrate into Yellowstone National Park for the summer.

Table 2. Mule deer population statistics in areas adjacent to Yellowstone National Park (YNP) during the 1980's.

Herd Unit	Estimated Population Size	Mean Harvest 1980's	Percent Population Change 1980's	Extent of Summer Migration Into YNP	Distance (km) of Winter Range From YNP	Sex and Age Class of Harvest (%)		
						Adult Males	Adult Does	Fawns
North of YNP[a]								
Upper Gallatin	---	130	increasing	extensive	borders YNP	---	---	---
Northern Range	3,000	596+[b]	+78	extensive	borders YNP	---	---	---
East of YNP								
South Fork Shoshone	4,800	792	+16	probable	27	78	21	1
North Fork Shoshone	2,500	242	+108	probable	48	85	15	tr
Clarks Fork	7,000	565	+123	probable	32	80	19	1
South of YNP								
Jackson	1,200-1,600	608	+250	probable	48	66	32	2
Targhee	800-1,000	77	+82	probable	24	83	17	0
West of YNP								
Sand Creek	1,337-1,983	256	counts sporadic	limited	16-48	70	30[c]	---
Total	20,637-21,883	3,266						
Mean			+110					

[a] An unknown number of deer from the Boulder and Stillwater Rivers may migrate into YNP as evidenced by several marked individuals (Claire Simmons, Mont. Dept. Fish Wildl. and Parks, Big Timber, pers. corres.).

[b] Does not include the harvest in a small portion of Hunting District 314 which lies on the northern winter range.

[c] Includes some fawns.

Sources: Foss (1987), Kuck et al. (1989), Hurley et al. (1989), Lockman et al. (1989).

South of Yellowstone National Park

About 2,000-2,600 mule deer occur in the Jackson and Targhee herd units south of Yellowstone National Park (Table 2). Population estimates have doubled during the 1980's but some of the increase may have been due to new methods of estimating herd size. Harvests averaged 685 per year during the 1980's.

West of Yellowstone National Park

Mule deer numbers for the Sand Creek herd averaged 1,599 for five trend counts during the 1980's. Few deer from the Sand Creek herd summer in Yellowstone National Park. The herd appears to be increasing.

White-tailed Deer

Occasionally white-tailed deer are seen in Yellowstone National Park during the summer, however, no winter sightings occur within the park. Healthy or expanding whitetail populations winter distant from areas wolves would likely occupy. Examples in Montana include Tom Miner Creek, Rock Creek, Yellowstone River downstream from Point of Rocks, Stillwater River, and the Boulder River. Examples in Idaho include Conant Creek and the Snake River. Therefore, wolf restoration is not predicted to affect white-tailed deer.

Moose

North and Northwest of Yellowstone National Park

Moose (Alces alces) on the northern range in Montana increased during the early 1980's with indices suggesting the population was relatively stable during the late 1980's (Swenson 1985a, Singer 1990). The moose population was estimated at 200 animals ten years ago (Houston 1982). A sightability-corrected estimate of population size is in progress. Average harvest north and northwest of the park was 116 moose (Table 3).

East of Yellowstone National Park

Moose populations east of the park are believed to be relatively stable except for the Thorofare area where they may have declined. An average of 44 moose were harvested annually (Table 3). The Thorofare area (bordering the southeast corner of the park) accounted for 55% of the moose harvest east of the park but permit numbers for this area were reduced during the 1980's. The Thorofare herd unit includes the best moose habitat. The North and South Forks of the Shoshone River include marginal habitat. In the Sunlight Basin herd unit losses of riparian habitat have occurred on private land.

Table 3. Moose population statistics in areas adjacent to Yellowstone National Park (YNP) in the 1980's.

Herd Unit	Estimated Population Size	Mean Harvest 1980's	Percent Population Change 1980's	Extent Summer Migration Into YNP	Distance (km) of Winter Range From YNP	Sex of Harvest (%) Adult Males	Adult Females	Calves
North of YNP								
Northern Range[a]	200	36	stable	includes YNP	includes YNP			
Upper Gallatin[b]	---	17	---	extensive	8-16	---75	17	8
Hebgen Lake[c]	---	63	---	extensive	includes YNP			
East of YNP								
Crandall	---	9	---	possible	---	100	---	---
Sunlight Basin	---	5	---	probable	3	100	---	---
North Fork Shoshone	---	3	---	probable	48	100	---	---
South Fork Shoshone	---	3	---	possible	48	100	---	---
Thorofare	---	24	---	includes YNP	includes YNP	100	---	---
South of YNP								
Jackson	2,300	329	greatly increased	verified[e]	---	76	21	3
Targhee	300	31	+130	probable	---	86	11	3
West of YNP								
Fall River	149[d]		stable	verified[f]	8	100	---	---
Big Bend	-----220	---------25	stable	probable	32	100	---	---
Junipers			stable	few/none	56	100	---	---
Island Park	192		stable	few/none	19	100	---	---
Total		545						

[a] Includes Montana hunt districts 316, 317, 318, 322, 328.
[b] Includes Montana hunt districts 306, 314.
[c] Includes Montana hunt districts 307, 309, 310, 361.
[d] Actual aerial counts.
[e] One radiocollared cow captured in the Buffalo Fork summered in YNP (Garvis Roby, Wyom. Dept. Game and Fish, Jackson, pers. corres.).
[f] 24% of marked moose migrated into YNP (Ritchie 1978).

Sources: Ritchie (1978), Houston (1982), Trent et al. (1984), Alt and Foss (1987), Chu et al. (1988a), Hurley et al. (1989), Lockman et al. 1989.

South of Yellowstone National Park

An estimated 2,600 moose occupy the Jackson and Targhee herd units south of the park. Trend counts for the Jackson herd increased 78% during the 1980's. Some of this increase may be due to the greater efficiency of the counts. Population models suggest the Jackson and Targhee herds increased 5% and 130%, respectively, during the 1980's. Average harvest was 360 moose per year (Table 3). Moose migrate from Jackson and Targhee herd units into Yellowstone. Moose migrations from the Jackson herd into Yellowstone National Park were verified by radiotelemetry. Biologists estimate 40% of the Targhee herd summers in Yellowstone National Park.

West of Yellowstone National Park

Counts of moose west of the park in Idaho averaged 435 in the early 1980's. No counts were made between 1982 and 1987. In December 1988, during a fixed wing survey 923 moose were observed. Harvests averaged 25 and other known losses (illegal kills, road kills, etc.) averaged seven per year (Table 3). Moose occupy four winter ranges 8-56 km (5-35 miles) from Yellowstone National Park. Marking studies suggested about 1/4 of the moose from the Falls River herd (nearest the park) spent the summer in Yellowstone National Park. A few animals from the other herds may also migrate into the park.

Bighorn Sheep

North and Northwest of Yellowstone National Park

During the last 20 years, bighorn sheep (Ovis canadensis) populations increased in Montana north of the park. The Mount Everts-Specimen Ridge herd increase fourfold from 1965-1979. Bighorns recolonized the Cinnabar Mountain herd in 1965 and between 1967 and 1977 increased from 16 to 120 animals. All northern populations remained stable or declined slightly during the 1980's except the Mount Everts-Specimen Ridge population which had a major dieoff in 1982 due to an infectious keratoconjunctivitis epidemic. A minimum of 406 bighorn sheep are found north of the park (Table 4). Harvests declined during the 1980's and averaged 22 legal rams. Most bighorns from the Tom Miner, Cinnabar Mountain, and Mount Everts-Specimen Ridge populations migrate into Yellowstone National Park.

East of Yellowstone National Park

Bighorn sheep from the Clarks Fork, Trout Peak, Wapiti Ridge, and Younts Peak herds east of the park increased an average of 7% during the 1980's (Table 4). These four herds total about 2,900 bighorns. Annual harvests averaged 91 legal rams. All four herds range near Yellowstone National Park but only limited migrations occur into the park. Wapiti Ridge is the exception with year-round ranges found in the Thorofare-Trident area of the park.

Table 4. Bighorn population statistics in areas adjacent to Yellowstone National Park (YNP) during the 1980's.

Herd	Estimated Population Size	Mean Harvest[a] 1980's	Percent Population Change 1980's	Extent Summer Migration Into YNP	Distance (km) of Winter Range From YNP
North of YNP					
Spanish Peaks (301)[b]	---	4	---	none	32
Taylor-Hilgard (302)	---	3	---	none	16
Cinnabar Mountain (300)	80-130	8	stable	most herd	13
Tom Miner (300)	80-100		declined	most herd	5-8
Mount Everts-Specimen Rdg. (303)	136[c]	2	declined[d]	most herd	includes YNP
Stillwater (500)	40-50	3	declined	none	48
Rosebud (501)	70-100	2	stable	possible	32
East of YNP					
Clarks Fork	500	13	stable	a few	5-8
Trout Peak	500	19	+14	a few	13
Wapiti Ridge	1,000	28	+14	includes YNP	includes YNP
Younts Peak	900	31	stable	a few	13-24
South of YNP			stable or		
Jackson	500	15	slight decline	none	56
Targhee	100	2	stable	a few	24
West of YNP					
No nearby populations					
Totals	3,906-4,016+	130			

[a] Harvest consists of 3/4-or-larger curl rams.
[b] Montana hunting district numbers in parenthesis.
[c] Actual count of sheep from Mount Everts along the Yellowstone River to the Specimen Ridge area.
[d] Population reduced by a pinkeye epidemic in 1982 (Meagher 1982).

Sources: Houston (1982), Keating (1982, 1985a), Meagher (1982), Hurley (1985), Irby et al. (1986), Hurley et al. (1989), Lockman et al. (1989), M. Meagher pers. commun.

South of Yellowstone National Park

Bighorn sheep from the Targhee and Jackson herds range south of Yellowstone National Park. Occasional bighorn sightings on Mount Sheridan (in the park) may include individuals from the Targhee herd. The Jackson herd probably ranges outside areas wolves would likely inhabit. The Targhee and Jackson herds consist of about 100 and 500 bighorns, respectively. Populations of both herds were relatively stable during the 1980's. Annual harvests averaged 17 legal rams during the 1980's (Table 4).

Mountain Goats

Less than 100 mountain goats (Oreamnos americana) inhabit areas adjacent to Yellowstone where wolves might occur (Table 5). About 8-12 mountain goats actually occur within the park. Some potential for mountain goat increase exists and Laundre' (1990) predicted Yellowstone National Park could possibly support 100-500 individuals.

Table 5. Nonnative mountain goat populations in areas adjacent to Yellowstone National Park (YNP)(adapted from Laundre' 1990).

Herd Unit	Estimated Population Size	Distance (km) from Yellowstone National Park
North of YNP		
Absaroka	100	0-24
Gallatin Range	a few	0-45
East of YNP		
Beartooths	150-180	19
South of YNP		
Palisades	250	80
West of YNP		
Spanish Peaks-Hebgen Lake	300	10-24
Total	800-830	

Information Needs

If wolves are reintroduced into Yellowstone National Park, more information will be required for ungulate herds subjected to both wolf predation and hunter harvest. The following state-of-the-art information should be obtained for each herd unit:

1. Annual aerial trend counts.

2. Annual aerial sex and age classifications.

3. Accurate sex and age information of hunter harvest.

4. Corrections of trend counts for animals not seen.

5. Annually updated harvest models predicting the effects of hunter harvest and wolf predation upon hunted ungulate herds.

6. Research models predicting effects of large-scale perturbations (wolves, fires, habitat alterations and acquisitions) upon ungulate herds.

An information rating index was used to quantify the information known on ungulates in the park area (Table 6). The index takes the form:

$$I = (D/(T*H))*100 \text{ where:}$$

I= Index in percent

D= Total number of data categories filled from all herds of a species

T= Total number of data categories

H= Total number of herds of a species

Currently, elk have the highest information rating index of 58%. Mule deer are rated at 42%, bison at 29%, bighorn sheep at 28%, and moose at only 18%. Mountain goats and white-tailed deer were not rated because they are rare and inconsequential to wolf recovery.

Table 6. Research and inventory during the 1980's of the ungulate herd units located within or immediately adjacent to Yellowstone National Park.

Species Herd Unit	Annual Aerial Count	Annual Sex/ Age Classi-fica-tion	Cementum Annuli Aging of Harvests	Radio-telemetry Studies of Move-ments/ Distri-bution	Manage-ment Harvest Models	Sight-ability Corrected Pop. Est.	Pop. Est. by Harvest Model	Research Pop. Model(s)
Elk								
Gallatin	X	X		X				
Northern	X	X	'88/89	X		X		2 habitat; 2 wolf effects
Madison-Firehole	X	X		X				
Clarks Fork	X	X	X[a]	X	X		X	
North Fork Shoshone	X	X	X[a]	X	X		X	
Carter Mountain	X	X	X[a]		X		X	
Jackson	X	X		X	X		X	wolf effects
Sand Creek	X	X	1986-89	X				wolf effects
Bison								
Northern	X	X						wolf effects
Mary Mountain	X	X						
Pelican Valley	X	X						
Mountain Goats								
Absarokas	X	X						
Gallatin	X							
Palisades		X						
Moose								
Northern range	X	X		X		In progress		
Upper Gallatin								
Hebgen Lake								
Crandall								
Sunlight Basin								
North Fork Shoshone								
South Fork Shoshone								
Thorofare								
Jackson	X	X		X	X		X	
Targhee	X	X			X		X	
Falls River		X		X[b]				
Big Bend		X	Not annually	X				
Junipers		X		X				
Island Park		X		X				

Table 6. Continued.

Species Herd Unit	Annual Aerial Count	Annual Sex/ Age Classification	Cementum Annuli Aging of Harvests	Radio-telemetry Studies of Movements/ Distribution	Management Harvest Models	Sightability Corrected Pop. Est.	Pop. Est. by Harvest Model	Research Pop. Model(s)
Bighorn Sheep								
Spanish Peaks								
Taylor-Hilgards								
Cinnabar Mountain	X	X		X				
Tom Miner	X	X		X				
Mount Everts-Bear Creek	X	X						
Stillwater	X	X						
Rosebud	X	X		X				
Clarks Fork		X	X					
Trout Peak		X	X	X				
Wapiti Ridge		X	X	X				
Younts Peak		X	X					
Jackson	X	X					X	
Targhee	X	X					X	
Mule Deer								
Upper Gallatin								
Northern range	X	Partial						
South Fork Shoshone	X	X	X		X		X	
North Fork Shoshone	X	X	X		X		X	
Clarks Fork/ Sunlight	X	X	X		X		X	
Jackson	X	X			X		X	
Targhee	X	X			X		X	
Sand Creek		X	Prior to 1987					

[a] A sample of the harvest are aged.
[b] Movement studies by visual marking collars (Ritchie 1978).

CURRENT DISTRIBUTION OF BEAVER IN YELLOWSTONE NATIONAL PARK

Susan L. Consolo and Donay D. Hanson, National Park Service,
Resource Management and Visitor Protection, P.O. Box 168,
Yellowstone National Park, WY 82190

EXECUTIVE SUMMARY

1. Much of Yellowstone National Park is marginal beaver (Castor canadensis) habitat, but beaver have persisted here since the park's inception.

2. In 1988-1989, 460 km (285 miles) of riparian habitat in Yellowstone National Park was surveyed to determine current presence and distribution of beaver. Forty-three stream segments or lakes had signs of current beaver activity, and 42 reliable observations of at least 27 individual beavers were collected.

3. Beaver are expected to be a secondary prey item if wolves (Canis lupus) return to Yellowstone; however, they could be vulnerable to the effects of predation in portions of the park where they are sparsely distributed.

4. More information and work is needed on the following: 1) levels of beaver trapping and poaching along park boundaries; 2) comparisons of historic records of beaver with trends in climate, hydrology, and riparian vegetation; and 3) development of a long-term monitoring program for beaver presence and abundance in Yellowstone National Park.

WOLF RECOVERY FOR YELLOWSTONE NATIONAL PARK: A Simulation Model

Mark S. Boyce, University of Wyoming, Department of Zoology and Physiology, Laramie, WY 82071

EXECUTIVE SUMMARY

A stochastic simulation model of gray wolf (Canis lupus) recovery for Yellowstone National Park was developed based upon existing data on wintering ungulates in the park and extrapolations from observations of wolf predation in other areas. The following conclusions may be reached based upon the behavior of this computer model:

1. Consummation of wolf recovery will depend in part on the number of wolves released in the park. There is a moderately high probability of extinction for the initial inoculum if fewer than ten wolves are released. Approximately 30 wolves should be released if assurance of wolf recovery is desired.

2. There is no combination of management choices where wolf predation has devastating consequences to elk (Cervus elaphus) populations in the park. The reason is that social behavior limits wolf densities so that the wolf population cannot attain total numbers high enough to depopulate the elk herd.

3. Wolf predation will cause a reduction in the number of bison (Bison bison), elk, moose (Alces alces), and mule deer (Odocoileus hemionus) in the park. Mean elk numbers may be expected to be 15%-25% lower if wolf recovery is accomplished. The effect of wolves on bison numbers will be less, with a reduction of only 5%-15%. Moose numbers on Yellowstone's northern range may decline if heavy hunter harvest is sustained in Montana. Mule deer may be locally susceptible to wolf predation, but the population is secure from extirpation because wintering areas exist where it is unlikely that they will suffer predation by wolves. It is assumed that wolves will have minor consequences to other vertebrates including bighorn sheep (Ovis canadensis) and pronghorn (Antilocapra americana).

4. Wolf recovery in Yellowstone National Park is not contingent upon discontinuing elk hunting north of the park in Montana. However, continued hunting when combined with wolf recovery will result in smaller ungulate populations in the park. Termination of elk hunting after wolf recovery could increase the number of elk wintering in the park by 5%-15%, while reducing variation in elk numbers by 20%-30%.

5. Ungulate numbers in Yellowstone National Park undergo substantial fluctuations due to climatic variation. The variance in ungulate numbers is predicted to decrease subsequent to wolf recovery, i.e., wolves will have a stabilizing effect on ungulate population size.

6. If the recovery zone includes additional public lands surrounding Yellowstone National Park, there is a substantially higher probability that wolf recovery can be accomplished. This additional land will increase the total number of possible wolf territories in the greater Yellowstone ecosystem and thereby reduce the probability of extinction for the introduced wolf population.

7. Wolf numbers are expected to fluctuate substantially, but they should eventually reach 50-120 animals under most management scenarios. If wolves are culled at 40% or more, there is a high probability that the wolf population will be extirpated. Once established, it is expected that 15-25 wolves may leave the park each year.

8. It is impossible to precisely predict the consequences of wolf recovery in the greater Yellowstone ecosystem because vagaries of climate can have enormous consequences to any ecological process. Any realistic model of wolf recovery must be stochastic, i.e., include random variation in certain ecological variables.

9. To refine predictions of the model, research is required to obtain detailed information on plant-herbivore dynamics, on moose and deer population dynamics in the park, and on the functional response of wolf predation. Implementation of wolf recovery should be accompanied by a carefully-designed monitoring program to test predictions of this model.

THE POTENTIAL IMPACT OF A REINTRODUCED WOLF POPULATION ON THE NORTHERN YELLOWSTONE ELK HERD

Edward O. Garton, Robert L. Crabtree, Bruce B. Ackerman, and Gerald Wright
University of Idaho, Department of Fish and Wildlife, Moscow, ID 83843

EXECUTIVE SUMMARY

There is extensive, long-term information available on the population dynamics of the northern Yellowstone elk (Cervus elaphus) herd. This data can be used to make fairly precise predictions of annual changes in elk population size as a result of winter severity (particularly snow hardness and depth), winter range size, the effects of fire on habitat, and hunter harvest outside the park. Information available from the literature on gray wolf (Canis lupus) population dynamics and feeding behavior allows one to make reasonable but less certain predictions about the effects that wolves would have on elk populations. Both sets of information were combined in a computer model to make projections of the dynamics of combined elk and wolf populations.

The projections of this model imply that the northern Yellowstone range could support about nine wolf packs, totaling approximately 75 animals. It was concluded that the elk population would decrease somewhat, but that the decrease would not exceed 10% under the conditions modeled. It was further concluded, assuming that other factors remain within normal bounds, that the relationship between predator and prey would be relatively stable and could therefore continue indefinitely.

This is an interim progress report. It is recognized that Yellowstone is a complex system which is difficult to represent with a model. Validation of the elk model, however, suggests that it captures important dynamics of the elk population during the past two decades. In addition, there will be several factors included in the final model which were excluded from this draft that will afford added realism. For example, an area of concern in the wolf submodel is social class (young of the year; dominant pack members; and subdominant, nonbreeding helpers). Wolves that are not pack members (e.g., loners and dispersers) are not included in the present model but will be included in the final model. Likewise, we have not included information on the impact of wolf predation on the populations of mule deer (Odocoileus hemionus), bighorn sheep (Ovis canadensis), pronghorn (Antilocapra americana), moose (Alces alces), and bison (Bison bison) occupying the same winter range; this information will be evaluated in the final model.

ESTIMATES OF THE POTENTIAL INTERACTIONS BETWEEN HUNTER HARVEST AND WOLF PREDATION OF THE SAND CREEK, IDAHO, AND GALLATIN, MONTANA, ELK POPULATIONS

David J. Vales and James M. Peek, University of Idaho
Department of Fish and Wildlife Resources, Moscow, ID 83843

EXECUTIVE SUMMARY

1. Estimates of the potential effects of gray wolf (Canis lupus) predation on the Gallatin, Montana, elk (Cervus elaphus) herd, and the Sand Creek, Idaho, elk herd are presented. These populations occupy Yellowstone National Park for a portion of the year, and are hunted when they occur outside of the park in fall and winter. Special hunts for both herds are used to control populations and prevent damage by elk on their winter ranges. We assumed that hunter harvest was accurately measured for these populations, and concluded that both population sizes are underestimated.

2. In the Gallatin elk herd, we estimated that up to 10 adult wolves could be supported at current elk population levels if hunter harvest were reduced from the 1983-1985 average of 436 elk to 300-400 elk, if harvest were restricted primarily to bulls, and if elk constituted between 75% and 90% of the wolf diet. If five wolves were present, harvest rates on antlerless (cow or calf) elk could be sustained at approximately half the current estimated level and produce a hunter harvest ranging from 350 to 450. This assumes no change from current population size. A compensatory response in the form of a 5% increase in survival of all sex/age classes of elk was of insufficient magnitude to change these conclusions.

3. If wolf predation on the Sand Creek population is confined to elk using Yellowstone National Park for 150 days, a hunter harvest of between 170 and 270 elk could be sustained on this population segment if ten wolves were present, but only by reducing cow harvest and increasing bull harvest. This harvest is similar to the 1980-1988 average of 219 elk. If wolves were allowed outside of southwest Yellowstone National Park, hunter harvest of Sand Creek elk could range from 640 to 770 with ten wolves on this population segment, a slight reduction from the 1980-1988 average of 738.

4. Our investigations suggested that heavily hunted elk populations can support wolves only if hunting pressure is directed primarily at bulls. We also believe these elk populations are larger than estimated, if the estimated harvest levels are reasonably accurate. It should be obvious that both predator and prey will have to be more intensively monitored than at present if both hunters and wolves are to occur together. Potential compensatory responses between the mortality factors and survival will be a major area for study if wolves again occupy this region.

SOME PREDICTIONS CONCERNING A WOLF RECOVERY INTO YELLOWSTONE NATIONAL PARK: How Wolf Recovery May Affect Park Visitors, Ungulates, and Other Predators

Francis J. Singer, National Park Service, Division of Research,
P.O. Box 168, Yellowstone National Park, WY 82190

EXECUTIVE SUMMARY

1. It is predicted that 7-9 gray wolf (Canis lupus) packs with fixed territories could occupy Yellowstone's northern winter range; another 1-2 packs could occupy the park's other winter ranges, and another 3-4 packs could be supported, but only if the latter packs were migratory or semimigratory. Overall, the park could support 8-11 wolf packs and portions of the territories of another 3-4 packs.

2. Opportunity for park visitors to view wild ungulates could decline slightly after wolf reoccupation of Yellowstone National Park, but viewing of habituated elk (Cervus elaphus), those that frequent developed areas, may increase since wolves will avoid these areas. Even though adult female ungulates with young change their habits due to wolf presence, they are typically shy and infrequently observed by park visitors even in the absence of wolves. Any changes in the distribution or behavior of other adult ungulates and older young are predicted to be minor.

3. The average relative abundance of ungulates on Yellowstone's northern range during the 1980's was 100 elk:10 mule deer (Odocoileus hemionus):2 bison (Bison bison):2 pronghorn (Antilocapra americana):1 bighorn sheep (Ovis canadensis):1 moose (Alces alces). Published studies indicate that the most to least vulnerable ungulates during winter would be pronghorn > bighorn sheep > mule deer > white-tailed deer (Odocoileus virgiana) > elk > bison > moose. However, since few mule deer, pronghorn or white-tailed deer winter within the park, and bighorns occupy steep rocky escape terrain, wolves are predicted to kill ungulates during winter on the northern range as follows: elk > bison > mule deer > moose > pronghorn > bighorn sheep.

4. Ungulates on three other ranges within Yellowstone National Park occur in a ratio of about 100 bison:95 elk:5 moose:1 mule deer. Wolves are predicted to kill ungulates during winter on these other ranges in the following order: elk ≅ bison > moose > mule deer.

5. Young ungulates of all species are vulnerable to wolves during summer. Parkwide ungulate ratios during summer are 100 elk:16+ mule deer: 8 bison:3+ moose:3 bighorn sheep:1 pronghorn:<1 white-tailed deer or

mountain goat (Oreamnos americanus). Wolves are predicted to kill ungulates during summer in the order of most to least: elk > mule deer > bison > moose > bighorn sheep > pronghorn > mountain goat.

6. Wolves may limit the numbers of a more vulnerable, less abundant prey species when wolf numbers are set by a less vulnerable, more abundant prey species. This potential exists for mule deer, pronghorns, and bighorn sheep. Each of these species is substantially less abundant than elk and is more vulnerable to wolves than elk in snow. However, these more vulnerable species are not predicted to be greatly reduced by wolves since mule deer and pronghorn winter near or north of Gardiner, Montana, where sustained pack activity by wolves is unlikely, and bighorn sheep are relatively secure from wolves near steep, cliffy terrain. Moose are of special concern since they are already harvested by humans at high levels on the northern range. White-tailed deer status should change little since whitetails generally occupy areas distant from likely wolf occupation areas. Bison on the northern range should be less vulnerable than other ungulates, but more vulnerable on the Mary Mountain and Pelican winter ranges due to deeper snows in these areas.

7. Yellowstone Park ungulates that winter in scattered thermal areas of a few hectares in size on the plateaus of the park's interior could be vulnerable to wolves since wolves could chase the ungulates into adjacent deep snows. Conversely, ungulates in the larger, relatively snow-free thermal areas should not be as vulnerable to wolves, since they will have more opportunity to outrun wolves.

8. Yellowstone Park's coyotes (Canis latrans) will probably decline and red fox (Vulpes vulpes) will probably increase after wolf recovery. Black bears (Ursus americanus) and wolves usurp carcasses from each other, and wolves occasionally prey upon black bears, but no published information suggests either species would be significantly affected at the population level. Wolverines (Gulo gulo) can be killed by wolves, but they can also escape from wolves by climbing trees which are numerous in Yellowstone Park. Little published information was available on possible competition between wolves and wolverines at carcasses. Minor effects upon grizzly bears (Ursus arctos) and mountain lions (Felis concolor) are predicted.

9. Humans disrupt activity at wolf dens which can cause wolves to move their pups. To avoid this disturbance many parks close the area surrounding wolf dens to human activity. Closures around wolf den sites tend to be smaller in forested habitats than in open areas. Closures vary from 2.6 km^2 in Voyageurs National Park and 13 km^2 in Isle Royale National Park (forested areas) to 41 km^2 in the tundra habitat of Denali National Park. In Yellowstone, den site closures will probably vary from no additional measures for dens in remote forested areas or in existing bear management zones to small closures at more accessible den sites.

POSSIBLE EFFECTS OF A RESTORED WOLF POPULATION ON GRIZZLY BEARS IN THE YELLOWSTONE AREA

Christopher W. Servheen, U.S. Fish and Wildlife Service, NS 312, University of Montana, Missoula, MT 59812

Richard R. Knight, Interagency Grizzly Bear Study Team, Forestry Sciences Lab, MSU Campus, Bozeman, MT 59717

EXECUTIVE SUMMARY

Brown bears (Ursus arctos) and gray wolves (Canis lupus) coexist throughout much of North America and Eurasia. A review of available literature on wolves and brown bears from the limitation of brown bear numbers by wolves or reports of limitation of wolf numbers by brown bears. Letters were sent to numerous scientists in the Soviet Union and Europe to solicit any opinions or unpublished information of wolf-brown bear interactions. None of those who responded indicated that wolves could pose a significant threat to brown bear populations. Reports of observed wolf-grizzly bear interactions from Alaska were summarized and did not indicate any significant detriment to either species due to interactions. In general, information indicates that the two species will interact over food sources but at few other occasions. Most interactions are characterized by mutual avoidance. Few instances of direct mortality to either species as a result of interactions are available.

In the Yellowstone area, wolves will change the numbers and distribution of ungulates that are used by grizzly bears as food. The significance of this change is speculative at this time. It is likely that any change to the ungulate population as a result of wolves would be gradual and grizzly bears would successfully adapt to this change over time. This change in ungulate numbers and distribution would be the most important impact of an increasing wolf population to grizzly bears in the Yellowstone area. It seems reasonable to assume that grizzly bears would adapt to these changes with little detrimental affect to grizzly numbers or survival.

EFFECTS OF RESTORING WOLVES ON YELLOWSTONE AREA BIG GAME AND GRIZZLY BEARS: Opinions of Fifteen North American Experts

Barbara Koth, David W. Lime, Jonathan Vlaming, Cooperative Park Studies Unit, University of Minnesota, Department of Forest Resources, 110 Green Hall, St. Paul, MN 55108

EXECUTIVE SUMMARY

The opinions of 15 North American gray wolf (Canis lupus) and wolf-prey researchers known for their studies of the interrelations among wolves, grizzly bears (Ursus arctos) and prey species were examined. Panelists addressed questions relating to the potential effects of a reintroduction of wolves to Yellowstone National Park on 1) wolf prey in the park, 2) the population of Yellowstone grizzly bears, and 3) big game hunting in areas surrounding the park.

A modified Delphi technique was used to conduct the study. This approach called for questions to be answered by experts followed by a collation of responses by project coordinators. Subsequent follow-up questionnaires were sent to the experts for further inquiry. Between late September and late December 1989, panelists were contacted three times and asked both general and specific questions about the issues. With each successive contact, their opinions were compiled, and new or more probing questions were addressed. The end product represented the panelists' best judgments on a variety of concerns and topics regarding the reintroduction of wolves to Yellowstone National Park. The following are the most salient results of their deliberations.

Major Findings:

1) Panelists unanimously agreed that wolves were part of the original Yellowstone National Park ecosystem.

2) The core wolf population should be centered in Yellowstone National Park, but the application of artificial or political boundaries might not sustain recovery levels.

3) A viable wolf population of about a dozen wolf packs that spend the majority of their time within Yellowstone National Park seemed realistic after the population has stabilized (within 20 years after reintroduction).

4) If wolves are reintroduced, extinction of any prey species, elk (Cervus elaphus), mule deer (Odocoileus hemionus), moose (Alces

alces), bison (Bison bison), pronghorn (Antilocapra americana), bighorn sheep (Ovis canadensis), and mountain goats (Oreamnos americana) was thought to be extremely unlikely.

5) There should be relatively minor changes in prey species' behavior and distribution if wolves were reintroduced to Yellowstone National Park.

6) Elk and mule deer should be the primary prey for wolves -- elk throughout the year, mule deer in summer. Other prey species should be relatively minor food sources.

7) Panelists unanimously agreed that wolves and grizzly bears can coexist. However, there were differing opinions about specific impacts of wolf reintroduction on grizzly bears, particularly whether wolf predation should provide grizzly bears with more protein from wolf-killed carcasses and a more consistent carrion supply. All panelists did call the overall impact on grizzly bears "slight" or "neutral."

8) Reduced big game hunting levels should not be an automatic requirement if wolves were restored to the greater Yellowstone ecosystem. Reduced hunting levels should be implemented only when necessary and then only in conjunction with wolf control measures and other prey population management tools.

9) More research is needed to better understand the interrelations among wolves, grizzly bears, prey species, and big game hunting in areas surrounding the park.

More specific findings addressed the following issues:

1) wolf numbers, 2) wolf movements, 3) general impacts of wolves on prey species, 4) specific impacts of wolves on large ungulates -- elk, mule deer, moose, bison, pronghorn, bighorn sheep, and mountain goats, 5) impacts of wolves on grizzly bears, and 6) effects of reintroduced wolves on big game hunting in areas outside Yellowstone National Park.

Wolf Numbers:

1) Panelists estimated a mean of 13 wolf packs would spend the majority of their time in Yellowstone National Park after the wolf population was established.

2) To most panelists, a large number of packs (over 25) seemed unlikely.

3) Panelists estimated a mean pack size of seven to ten individuals.

4) Panelists estimated an average total in-park wolf population of 150 individuals would spend the majority of their time in Yellowstone National Park.

5) Panelists estimated five to ten additional packs would attempt to establish territories located primarily outside Yellowstone National Park.

Wolf Movements:

1) Wolves have the potential to locate nearly anywhere in Yellowstone National Park, but the most likely area of wolf colonization would be in the north-central region; some areas would be lightly occupied, if at all.

2) A stable territorial mosaic of wolf packs should develop within 20 years after reintroduction. Territories should change in response to changing prey distributions, prey abundance, and pack size and dominance.

3) In summer, most wolves should be within park boundaries and wolf activity should concentrate around den sites and should take advantage of calving by mule deer, elk, bison, and moose within Yellowstone National Park.

4) In winter, wolf packs should hunt mainly in areas of low elevation where ungulates, particularly elk, aggregate.

5) A consensus could not be reached concerning when packs might leave the winter range, how often packs would visit major prey areas within their territories in winter, and whether winter hunting would commonly occur as a pack or periodically as a subunit of the pack.

General Impacts of Wolves on Ungulates:

1) Ungulate species, in the order of most to least vulnerable, were as follows: elk, mule deer, moose, bison, pronghorn, bighorn sheep, and mountain goats.

2) Elk were expected to be the primary prey species for wolves in all seasons. Secondary prey would be mule deer, moose, and bison.

3) Most distribution changes of prey populations should be relatively local changes in animal movements, implying little geographical and behavioral distribution impacts.

Impacts of Wolves on Elk:

1) Elk were expected to be the primary prey for wolves in all seasons.

2) There should be moderate or little change in elk behavior and distribution if wolves were reintroduced to Yellowstone National Park.

3) Wolf predation should induce an initial decline in elk numbers that should reduce nutritional stress and improve reproduction.

4) Ten years after wolf reintroduction, assuming a wolf population of ten packs of ten wolves each, a reduction in the elk population of less than 20% was expected.

Impacts of Wolves on Mule Deer:

1) Mule deer might be a primary prey for wolves during the summer and a secondary prey for the rest of the year.

2) There should be moderate or little change in mule deer behavior and distribution if wolves were reintroduced to Yellowstone National Park.

3) Ten years after wolf reintroduction, assuming a stable wolf population of ten wolf packs of ten wolves each, a reduction in the mule deer population of between 20% and 30% was expected.

Impacts of Wolves on Moose:

1) Moose were considered potential prey for wolves, although panelists felt there was not enough information to formulate an opinion on whether moose would provide an important prey base for wolves.

2) There should be moderate or little change in moose behavior and distribution if wolves were reintroduced to Yellowstone National Park.

3) Ten years after wolf reintroduction, assuming a stable wolf population of ten wolf packs of ten wolves each, a reduction in the moose population of between 10% and 15% was expected.

Impacts of Wolves on Bison:

1) Panelists held widely varying opinions about the level of utilization of bison as wolf prey. Wolves might prey on bison only occasionally, but bison also had the potential to be major prey depending upon a variety of factors such as type of wolf reintroduction and hunting skills developed over time.

2) There should be little or no change in bison behavior and distribution if wolves were reintroduced to Yellowstone National Park.

3) Ten years after wolf reintroduction, assuming a stable wolf population of ten wolf packs of ten wolves each, a reduction in the bison population of less than 20% was expected.

Impacts of Wolves on Pronghorn, Bighorn Sheep, and Mountain Goats:

1) Pronghorn, bighorn sheep, and mountain goats would be available prey for wolves but would not likely be an important food source for them.

Impacts on Grizzly Bears:

1) Wolves would provide some carrion for grizzly bears, and some occasional wolf-bear conflicts might arise during competition for carcasses. Direct interspecies killing should be insignificant.

2) Grizzly bear distribution and behavior were not expected to change if wolves were reintroduced to Yellowstone National Park.

3) The omnivorous food habits of grizzly bears mean that grizzly bear densities are not strongly linked to ungulate densities.

Impacts of Wolves on Big Game Hunting in Areas Surrounding the Park:

1) Panelists were evenly split over whether reduced hunting levels would be a necessary concession that comes with wolf restoration.

2) Elk harvest levels might be reduced after wolf restoration, but, at present, elk are generally hunted below maximum sustained yield. No consensus was reached regarding mule deer, bison, and moose hunting. Projections indicated that harvest levels for pronghorn, bighorn sheep, and mountain goats would not need to be reduced.

3) According to the majority of panelists, sport hunting for any prey species should not have to be eliminated, even at higher pack levels (25 packs or more).

4) All panelists agreed that it cannot be assumed that a reduction in hunting would simply make up for wolf kills in an additive manner, because sport hunting and predation target different animals.

5) Hunting and wolf population control must be discussed as integrated factors. The objective outside Yellowstone National Park should be wolf population control, not eradication.

PROPOSED STUDIES FOR 1990

John D. Varley, National Park Service, Division of Research, P.O. Box 168, Yellowstone National Park, WY 82190

Recognizing that a number of concerns remain, these topics will be investigated in 1990:

- How vulnerable might moose on the northern range be to reduction by combined human harvest and wolf predation?

- Elk calf mortality - what kills the calves and when?

- How will wolves affect the Jackson Hole elk herd? (computer modeling)

- How can DNA fingerprinting help us positively separate wolves, coyotes, and domestic dogs, and characterize how closely wolves and coyotes of Yellowstone are related to others in the northern Rocky Mountains?

- What does the paleontological and archeological literature tell us about wolf prehistory in the greater Yellowstone area?

- What can a sophisticated computer model tell us about mule deer and elk population dynamics in greater Yellowstone?

- What effects will the 1988 fires and winter range acquisition have on wolf/elk predictions? (computer modeling)

- How will wolves and grizzly bears affect each other in the Firehole River area, where bison as carrion are seen as critical to grizzly bear welfare?

- What is the small mammal prey base for wolves, and what percentage of a wolf's diet might consist of small mammals in Yellowstone?

- How will wolf recovery affect the region in social and economic terms?

Numerous other questions may be addressed by future studies.

ACKNOWLEDGEMENTS

The able assistance and support of the following individuals were essential to the completion of this document: project coordinators John D. Varley and Steve H. Fritts; editorial and logistical staff Susan M. Mills, Lauryl J. Mack, Sarah E. Broadbent, and Norman A. Bishop; and technical support staff Renee S. Evanhoff, Mary Beth Martinec, Pat A. Deeg, Donay D. Hanson, and Catherine J. Smith. Thanks also to Yellowstone's computer support staff for bearing with us during the more trying times. Printing services provided by Government Printing Office, Billings, Montana.

REVIEWERS

Draft portions of this document were sent to the following individuals for their comments and review.

National Park Service
Norman Bishop
Wayne Brewster
Douglas Houston
Dan Huff
Dick Knight
Mary Meagher
Michael Ruggiero
Rich Klukas
John Varley
Susan Mills
Francis Singer
Stu Coleman
Paul Schullery
John Mack
Sue Consolo

U.S. Fish and Wildlife Service
Steve Fritts
Kemper McMaster
Chuck Lobdell
Jay Gore

U.S. Forest Service
Kirk Horn

Universities
Lee Metzgar, University of Montana
Mark Boyce, University of Wyoming
Dave Vales, University of Idaho
James Peek, University of Idaho

State Fish and Game Departments
Ruth Gale, Idaho
Jim Yorgason, Wyoming
Garvis Roby, Wyoming
Kurt Alt, Montana
Tom Lemke, Montana

COVER

Original cover artwork designed by Dave Cowan, Yellowstone National Park. Color printing provided by Denver Service Center.